# TECHNICAL REPORT

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## Pulsed field magnetometry

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

# PULSED FIELD MAGNETOMETRY

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IEC 62331, which is a technical report, has been prepared by IEC technical committee 68: Magnetic alloys and steels.

The text of this technical report is based on the following documents:

| Enquiry draft | Report on voting |
|---|---|
| 68/299/DTR | 68/303/RVC |

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

# INTRODUCTION

In order to measure the full magnetic characterization of magnetically hard (permanent magnet) materials, it is necessary to apply a magnetic field sufficient to saturate the test specimen of magnetic material.

The generation of this magnetic field can become a practical limiting factor and can determine the appropriate measurement techniques.

Super-conducting magnets can generate very high static or slowly changing magnetic fields but their complexity, high capital outlay and running costs, requiring cryogenic gases make them far from ideal. It is necessary to change fields slowly to avoid “quenching” the super-conducting magnet.

Conventionally wound electro-magnets with slowly changing magnetic fields have a significant heat generation problem through $I^2R$ loss. This can be alleviated through the use of a high relative permeability “iron yoke”. However, saturation of the iron prevents maximum characterization of the loop of rare earth permanent magnet materials to be determined.

A pulsed field system utilizing conventional conductors minimizes heating effects by limiting field durations and by limiting heat generation to acceptable levels. Fields up to 40 Tesla (T) can be generated in this way.

Careful consideration, however, must be given to the instrumentation and method to take account of dynamic effects due to the short duration of the magnetic field.

While work on pulsed field magnetometry is carried out in many parts of the world, the two main groups are MACCHARETEC [ref. 29][1] in Europe and EMAJ [ref. 30] in Japan. The approach adopted in Japan is one of supporting a standard with fixed specimen sizes, magnetic field strengths and frequencies in a limited number of configurations.

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1 References in square brackets refer to the bibliography.

# PULSED FIELD MAGNETOMETRY

## 1 Scope and object

This Technical Report reviews methods for measuring magnetically hard materials using pulsed field magnetometers.

The methods of measurement of the magnetic properties of magnetically hard materials have been specified in IEC 60404-5 for closed magnetic circuits and in IEC 60404-7 for open magnetic circuits. The measurement result of the magnetic properties of magnetically hard materials at elevated temperatures is given in IEC 61807.

Pulsed field magnetometers have been developed to provide rapid measurement facilities to match high speed production rates with 100 % quality control.

The object of this report is to describe the principles and practical implications of pulsed field magnetometry in order to enable the full potential of the technique to be considered, including its application using small and large magnets of varying geometries, to various magnetic field strengths and frequencies.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60404-5:1993, *Magnetic materials – Part 5: Permanent magnet (magnetically hard) materials – Methods of measurement of magnetic properties*

IEC 60404-7:1982, *Magnetic materials – Part 7: Method of measurement of coercivity of magnetic materials in an open magnetic circuit*

IEC 61807:1999, *Magnetic properties of magnetically hard materials at elevated temperatures – Methods of measurement*

IEC 60404-14:2002, *Magnetic materials – Part 14: Methods of measurement of the magnetic moment of ferromagnetic material specimen by the withdrawal or rotation method*